WESTLAND
RESOURCE GROUP

PROJECT NO: 89-047

TERRAIN ANALYSIS: GEOTECHNICAL AND ENVIRONMENTAL CONSIDERATIONS FOR THE SKEENA-KITIMAT TRANSMISSION LINE

Prepared for:

B.C. Hydro
Environmental Resources
Vancouver, B.C.

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D. Maynard, M.Sc.
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EXECUTIVE SUMMARY

A large number of route alternatives have been proposed within two main corridors, along the east side of the valley following the existing transmission line and along the west side of the valley. The surficial landscape of the Terrace-Kitimat valley is somewhat complex and a variety of terrain conditions and geomorphic processes which pose varying degrees of constraints and/or hazards to transmission line location, construction, and maintenance are encountered. The most significant problems of terrain are at the proposed crossing sites of major streams and rivers. At these locations, geotechnical concerns involving threats to the integrity of the line from flooding, erosion, and landsliding have to be considered as environmental concerns involving possible sedimentation of important fish habitat.

The eastern route option features encroachment of significant wetland terrain, numerous crossings of relatively confined tributary streams, and a major traverse of Kitimat River floodplain.

Three alternatives are proposed at the north end of Lakelse Lake. Segment 2 - 6 crosses a wide section of deep, soft organics, segment 3 - 6 significantly encroaches on Sockeye and Williams Creeks floodplains, and segment 4 - 7 crosses higher on the Sockeye - Williams fan where flooding and wetlands are less extensive.

Segment 7 - 8 is mostly alongside the existing line; areas of minor erosion and potential instability are isolated and have been dealt with in the past. Crossings of three major creeks and Kitimat River are all at confined, stable locations; the proposed Schulbuckhand crossing is much more secure than the existing one. An unstable area south of Kitimat River on the existing line is avoided.

Segment 8 - 10 also follows the existing line, mostly across the low terrace and fans which are very wet. Segment 9 - 10 parallels 8 - 10, farther to the east, where it avoids a lot of the excessive wetness of the latter but encroaches on limited sections of rockfall, potential slope erosion, and glaciomarine deposits.
Segments 10 - 11 and 10 -12 cross Kitimat River floodplain on either side of the existing line. Hazards posed by potential channel shifting and lateral bank instability probably create the greatest threat to the integrity of transmission lines in the entire study area. Segment 10 - 12, on the south side of the line, is closer to the actively eroding channels. Potential erosion and mass movement are recognized on dissected glaciomarine terrain at nodes 11 - 12.

The western route option crosses extensive glaciofluvial deposits with intervening areas of glaciomarine muds. In places, steep, potentially unstable bedrock-controlled slopes are encountered. Three large rivers, Lakelse, Wedeene and Little Wedeene, are to be crossed.

Potential terrain problems on segment 1 - 13 are minor erosion and foundation concerns on thick glaciomarine muds and the crossing of Lakelse River. At the proposed crossing site there are good bank foundations and a relatively narrow floodplain.

Two alternatives are suggested south to Wedeene River. There are only minor erosion concerns on segment 13 - 15; node 15 is located on dissected glaciomarine muds which show evidence of potential erosion and mass movement. Segment 13 - 16 mostly traverses stable lower slopes or the subdued granular surface. It should be sufficiently set back from the base of unstable slopes and the debris torrent fans. It also crosses a wide section of Coldwater Creek floodplain. Connectors 14 - 15 and 15 - 16 both traverse thick, dissected glaciomarine deposits bordering Wolf Creek which show considerable evidence of potential erosion and mass movement.

Segments 15 - 21 and 16 - 22 parallel each other on either side of Wedeene River. Mostly stable terrain underlies the former whereas the latter encroaches on significant areas of active and potential erosion and mass movement and includes a crossing site where the floodplain is wide and wet.

Three other alternative crossing locations are proposed in this area. The river is most confined and the channel sides stable on segment 17 - 18. A wider floodplain and unstable, west terrace scarp occur on segments 19 - 20 and 21 - 22.

Continuing south, segments 21 - 23 and 22 - 24 parallel each other on either side of Wedeene River. Good foundation conditions and few constraints occur on segment 21 - 23. Segment 22 - 24 crosses the incised and potentially unstable valley of Raley Creek then traverses isolated areas of active and potential erosion and mass movement on glaciofluvial and glaciomarine dissected terrain. A proposed crossing location on segment 23 - 24 has mostly stable, subdued ground on both banks; a low, potentially floodable terrace exists on the south side.

Three crossing alternatives are proposed for Little Wedeene River. All three cross similar terrain north of the river but segment 24 - 27 encroaches on more of a potentially erodible scarp and unstable ravine but also descends at a stabler section of the north bank scarp. The westernmost segment (24 - 25 -27) crosses the river at its most confined section, but then must traverse a high dissected glaciofluvial scarp on the south side of the valley. The active channel is relatively narrow, with an occasional floodplain on the north side, at the two easternmost crossings.

Terrain problems on segment 27 - 11 include an unstable, bedrock-controlled slope which can be avoided and thick deposits of dissected glaciomarine muds which have to be traversed.

Segment 12 - 28 is common to both eastern and western route options. It mostly traverses the bedrock valley wall where sections of active and potential mass movement occur. However, along most of the proposed right-of-way stable, less-steeply sloping ground is available for route modification. At the proposed crossing of Anderson Creek, solid bank foundation conditions exist back from the relatively confined, unstable canyon walls.

In summary, from a terrain perspective, Route B offers a greater choice for selecting a secure location for the proposed transmission line. On Route B there are options for selecting stable crossings of the three major rivers, for selecting predominantly stable corridor segments, and for avoiding or spanning any unstable sites which may be encountered. However, on Route A, two major terrain concerns are unavoidable: the wetland-floodplain area north of Lakelse Lake and the wide, unstable floodplain of Kitimat River.

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1.0 INTRODUCTION

Terrain analysis was carried out to assess the environmental and geotechnical effects of locating, constructing, and maintaining a new 287 kV transmission line between existing substations near Terrace and Kitimat, B.C. Terrain conditions and geologic hazards along a number of proposed route alternatives were examined at a reconnaissance level of reliability. The distribution of these terrain features is shown on 1:50,000 scale maps of the Terrace-Kitimat valley (Appendix A).

The surficial geology of the valley is fairly complex, reflecting a complicated period of deglaciation whereby thick sequences of glaciofluvial gravels and glaciomarine muds infilled the lowlands. In subsequent post-glacial time, erosion and mass movement have modified many of these unconsolidated slopes in the valley bottom; erosion, landsliding, and snow avalanching also occur on the steep, bedrock-controlled valley sides. Flooding is the other major geological process which poses a hazard to development in certain parts of the valley. In many areas, the frequency of occurrence and magnitude of event for the various geological processes have been altered as a result of man's activities in the valley and on adjacent sideslopes.

2.0 METHOD OF STUDY

The scope of the study is at a reconnaissance level of reliability which does not involve detailed field work. Terrain analysis was done according to accepted provincial standards - Terrain Classification System for British Columbia (Revised Edition), (B.C. Ministry of Environment, 1988). The distribution of terrain (surficial) materials and landforms of the study area has been adequately described at the reconnaissance level by two sources (Clague, 1984 and B.C. Ministry of Environment, no date). Using this information as base data, one day (November 4, 1989) was spent examining all the route alternatives by helicopter.

Subsequently, the various routes were thoroughly studied by stereoscopic examination of 1:20,000 black-and-white aerial photographs (taken in 1984 and 1988). The combination of information obtained from the published maps, field observations, and photo interpretation allowed for an accurate assessment of the occurrence of significant terrain conditions and geomorphic processes.

Polygons or map units, enclosing areas of specified terrain features and/or areas affected by geomorphic processes, were delimited on the aerial photos and then transferred to 1:50,000 topographic base maps. Features or conditions of the terrain which are described include: occurrence of wetlands and/or organic deposits, occurrence of fine-textured soil materials, topography, and presence of surface or near-surface bedrock. Hazardous geomorphic processes which are described include: active and potential landsliding, active and potential surface erosion, flooding, and snow avalanching. In addition, landslide or rockfall depositional areas and debris torrent runout zones are shown.

3.0 SURFICIAL GEOLOGY

The study area occurs within the Kitsumkalum-Kitimat trough, a major north-south valley which served as a main channel of ice movement during Pleistocene glaciation and as a fjiord in post-glacial time. During the Fraser glaciation, the last major ice advance, ice flow in this area was southward. Previously deposited sediments were largely eroded by the scouring ice sheet although, in places, glacial till was deposited over underlying materials. Valley sideslopes were scoured to bedrock in places; elsewhere till was plastered onto rock slopes.

With the onset of deglaciation, the glacier in the Kitsumkalum-Kitimat trough retreated in contact with the sea (Clague, 1984). Glaciomarine muds accumulated on the submerged valley floor away from the glacier front. Rapid retreat of the ice was interrupted by two temporary standstills (represented by the large deltaic platforms north and south of Lakelse Lake) where deltas consisting of sand and gravel built in contact with the ice front. Streams entering the trough

from tributary valleys constructed smaller deltas at successively lower elevations as the land rebounded during and shortly after deglaciation (ibid).

In many areas of the valley bottom, the glaciomarine and deltaic (glaciofluvial) sediments were locally eroded and/or covered by alluvium in post-glacial time. Slopes above the marine limit (approximately 200 m elevation, Clague [1984]) are mainly covered by sandy moraine or rubbly, bedrock-derived colluvium or have bedrock at the surface. Organic sediments have also accumulated in recent time. Notable deposits occur at the north and south ends of Lakelse Lake on poorly drained glaciomarine muds.

Geomorphic processes initiated after deglaciation. These processes were likely most active immediately after the ice left as the land rebounded above the sea and slopes were left oversteepened and unvegetated. Processes of landsliding, erosion, flooding, and snow avalanching continue to the present. Landslides are mainly associated with steep scarps eroded in unconsolidated sediments (often bordering main creeks and rivers), sloping glaciomarine terrain, and steep bedrock-colluvial slopes. Active erosion is normally associated with gully, stream, and river banks and gullied terrain - particulary glaciomarine sediments, kame terraces, and till slopes. Flooding is common on all major streams and rivers and the hazards associated with it include bank erosion and channel shifting as well as overbank flow. Snow avalanching is mainly restricted to steep, upper valley slopes although in a few places avalanche runout extends onto lower slopes.

Activities of man in some places in the Terrace-Kitimat valley have affected the degree and magnitude of activity of some geomorphic processes. Although it is difficult to quantify these changes, there is little doubt that logging road development and clearcutting has caused an increase in landsliding on many steep slopes. Two large mudflows in glaciomarine muds occurred in 1962 near the north-east end of Lakelse Lake (Clague, 1984). Their direct cause is not stated but they occurred in areas of highway construction. Accelerated erosion is also a result of road building and logging adjacent to watercourses and on gullied terrain, particularly that underlain by fine glaciomarine sediments. Flooding potential of many streams and rivers has also

been altered. Tributary streams on the east side of Lakelse Lake have been diked, thereby reducing their flood hazard. The highway confines the east bank of Kitimat River, somewhat protecting the cutoff floodplain east of the road from overbank flow but leading to more erosion and higher water or the west side. Flood peaks on many of the larger tributaries may also be higher now that their watersheds have been extensively logged.

4.0 TERRAIN CONDITIONS AND PROCESSES: ENVIRONMENTAL AND GEOTECHNICAL IMPLICATIONS

Following is a description of the various mapped conditions and processes of the terrain with a discussion of environmental and geotechnical constraints or hazards associated with each:

WETLANDS - depressional areas which are poorly drained for most of the year; inundation from high water table or lake or stream flooding is the main constraint but soft, compressible soils are also common.

Map Symbols

- W1 -dominantly organic materials greater than 1m thickness
- W2 -organic deposits of variable extent and thickness (40-150 cm)
- W3 -thin organics (less than 1m) and poorly-drained mineral soils; overbank silts and fine sands occur on wet floodplains, glaciomarine muds underlie other valley bottom depressions.

FINE-TEXTURED SURFACE MATERIALS -

glaciomarine muds consisting of a mixture of clay, silt and minor sand. These have relatively high bearing strengths when dry but virtually none when saturated. They may liquefy and flow, even on gentle gradients, when disturbed.

Map Symbols

- f1 -dominantly thick (greater than 2m) deposits
- f2 -deposits of variable thickness - 50 - 200 cm
- f3 -disturbed or reworked muds as the result of saturation.

TOPOGRAPHY - Steep uniform slopes and broken, irregular topography are identified because they may be associated with potential mass movement and erosion and also may pose some access or construction constraints.

Map Symbols

s -slopes dominantly greater than 70% (35°)

k -slopes dominantly between 50 - 70% (26 - 35°)

h -hummocky and/or ridged terrain

d -highly dissected terrain; gullied, channelled or pitted surfaces

BEDROCK - bedrock is often an excellent foundation material but is more difficult and expensive to excavate (for access roads or tower construction)

Map Symbols

r -bedrock at or within 50 cm. of the ground surface

MASS MOVEMENT-

with high local relief and abundant precipitation the area is susceptive to landslide failures. On steep, bedrock-controlled slopes, the main landslide types are debris slides and flows, debris torrents (channelized flows), and rockfalls. On thicker, valley-bottom surficial deposits, slides are common on oversteepened terrace scarps and on glaciomarine deposits, particularly where gullied. Landslides can threaten tower foundations, access, and worker safety.

Map Symbols

R- slopes which show evidence of active landsliding either in their natural condition or following disturbance (road construction, clearcutting).

PR- slopes which are potentially susceptive to landsliding; they are steep and/or have evidence of small failures or on-going slow movement. Disturbance to the slope could cause landsliding.

EROSION - with high local relief, fine-textured soils, and abundant precipitation the area is susceptible to surface erosion. Erosion is possible on any gullied terrain, on steep granular slopes, on glaciomarine sediments (particulary where they slope or are dissected) and on oversteepened and undercut gully, stream, and river banks. Exposing bare soil during construction increases erosion potential. Downslope or downstream sedimentation is the main result of slope erosion.

Map Symbols

E - active or on-going soil erosion

PE - terrain which is potentially susceptible to surface erosion; slopes, gullies and stream banks appear stable but could erode if disturbed by road construction or deforestation.

DEPOSITIONAL AREAS -

along with active landsliding, surface erosion, and snow avalanching on slopes, areas of active deposition from these processes should also be considered hazardous. Where on-going accumulation from landslides or snow avalanches is evident worker safety, towers, and access roads may be threatened.

Map Symbols

D - toe-slope areas regularly receiving deposition from upslope debris slides or flows or rockfalls.

Rt - fans built at the mouths of steep-gradient gullies subject to debris torrent flows; debris deposition, erosion, and channel shifting may occur anywhere on the fan.

SNOW AVALANCHING -

The rapid downslope movement of snow, ice, and incorporated debris occurring in areas of high local relief and moderate to high snowfall. Winter and spring avalanche activity poses a direct hazard to tower integrity, access, and worker safety.

Map Symbols

A - Slopes subject to regular snow avalanching; includes zones of initiation, transportation, and deposition

FLOODING - Climate and physiography of the study area make floods inevitable. Potential flood areas include active channels and low terraces of rivers and streams and some alluvial fans at the mouths of tributary valleys. Hazards from flooding include overbank inundation, channel shifting, and laterally eroding banks. Flooding typically is of two types: fall-winter floods triggered by intense rainstorms, sometimes accompanied by rapid snowmelt and spring-early summer floods caused by melting of the winter snow pack.

Map Symbols

F - areas subject to frequent flooding - 1 to 3 year return

O - areas subject to occasional flooding - less than 50 year return

5.0 PROPOSED ROUTE ALTERNATIVES: TERRAIN CONDITIONS AND HAZARDS

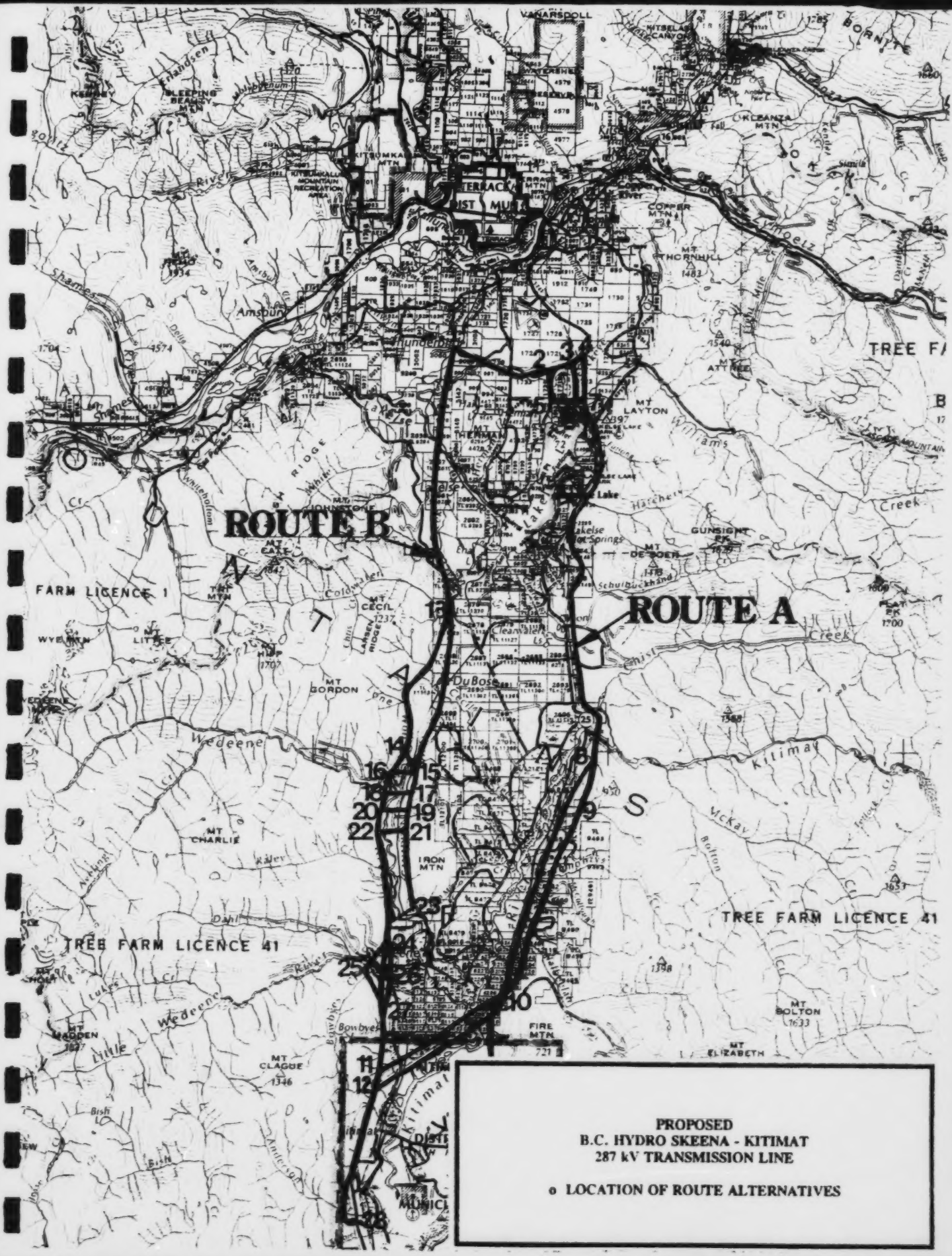
(See LOCATION OF ROUTE ALTERNATIVES MAP following page 7)

Segment 1 - 2

- subdued, thick, glaciomarine muds underlie most of this segment paralleling the existing transmission line. A few small, shallow wetlands are crossed. Minor erosion potential on incised channel banks; no significant constraints or hazards.

Segment 2 - 4

- this segment, paralleling the existing transmission line, is on a near-level deltaic surface underlain by well-drained sands and gravels; no constraints or hazards.


ROUTE B
ROUTE A
FARM LICENCE 1
TREE FARM LICENCE 41
TREE FARM LICENCE 41
PROPOSED
B.C. HYDRO SKEENA - KITIMAT
287 kV TRANSMISSION LINE
o LOCATION OF ROUTE ALTERNATIVES

Segment 2 - 5

- the route crosses a large incised gully with potential erosion on the moderately steep sidewalls and then angles down a moderately steep, stable slope; no significant constraints or hazards.

Segment 3 - 6

- this route parallels the existing transmission line alongside the highway. It drops down the potentially erodible granular scarp (photo 1) and then crosses the wetland floodplain of Sockeye and Williams Creeks. Organics are variable in extent and thickness but are probably underlain by alluvial gravels. Disturbance to the floodplain and hydrologic regime of Sockeye Creek has occurred through the location of the highway and power line (photo 2). This new segment would encroach on much more of the floodplain. Flooding by overbank inundation and high water table is the main hazard.

Segment 4 - 7

- this segment crosses the same terrain as segment 3 - 6 but farther upstream on the creeks where wetlands and flooding may be less extensive and foundation conditions may be more secure. Erosion potential exists on the scarp (photo 1) and flooding is probable over most of the lowland. Node 7 is in the centre of a deep organic deposit.

Segment 5 - 6

- this segment crosses a deep organic wetland and the active floodplain of Williams Creek. Very poor foundation conditions exist in the wetland where the organics overlie saturated glaciomarine muds. Lake flooding and high water table cause regular inundation. The creek floodplain is subject to frequent flooding.

Photo 1. Potentially erodible, moderately-steep granular scarp down which segments 3 - 6 and 4 - 7 would traverse. View southwesterly from near node 4 toward existing transmission line.

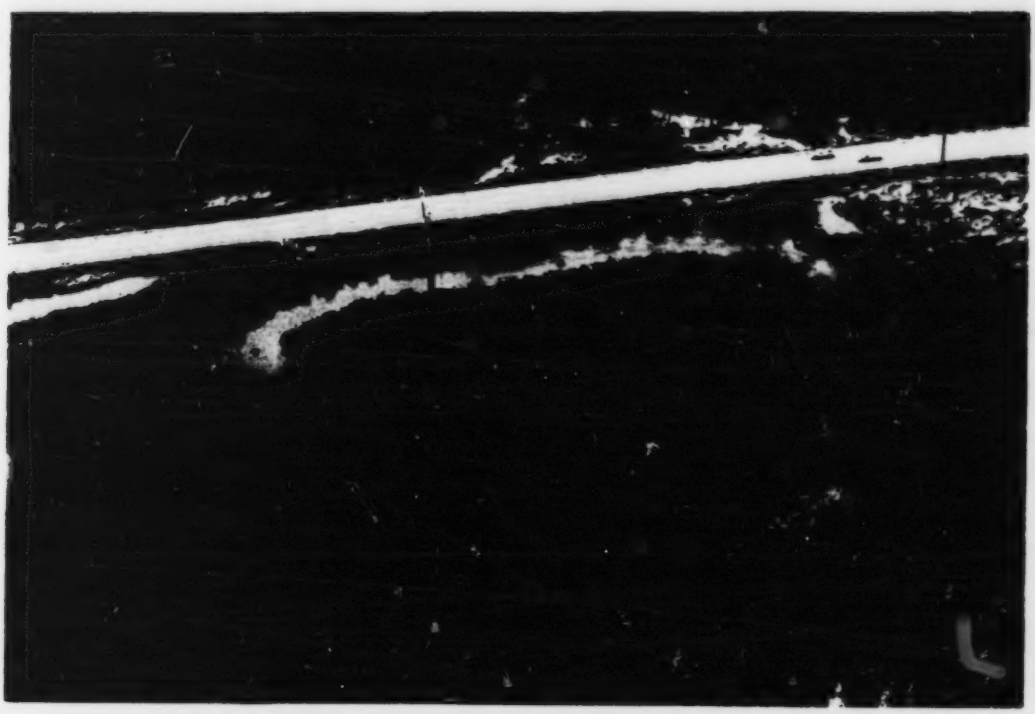


Photo 2. Floodplain of Sockeye Creek is constricted by the location of the highway. Segment 3 - 6 would traverse the centre-foreground of the photo, encroaching on a significant portion of the floodplain.

Segment 6 - 7

- this route parallels the existing transmission line alongside the highway. It crosses shallow wetlands, probably overlying alluvial gravels except at node 7 where deep organics are encountered. Flood hazard is mainly inundation by overbank flow, high lake levels, and/or high water table and is most frequent adjacent to Williams Creek.

Segment 7 - 8

- the route is on the upslope side of the existing transmission line east of the highway. For the most part it traverses gently to moderately steep lower valley slopes. It is above the old glaciomarine landslides of 1962. Potentially erodible slopes are crossed in a few places; these are mainly associated with gullied till. Bedrock outcrops are sporadic, occurring on steep slopes and as knobs or ridges.

  Three main creeks and Kitimat River are crossed but all at relatively confined sections where they can be easily spanned (photos 3 and 4). Photo 5 illustrates the selection of stream crossing sites. Flooding by channel shifting may threaten existing towers on Schulbuckhand fan but the channel is confined and easily spanned at the fan apex where this new segment is proposed. Most of the potentially hazardous areas, floodplains and gullied slopes, are of restricted width and therefore, can be crossed with little impact. A small area which may be troublesome is an actively eroding gravel scarp (old gravel pit) at Hatchery Creek where the room between this slope and the existing line is limited (photo 6).

  South of Kitimat River the route is proposed to climb the ridge to stay above an actively failing and eroding gullied till slope. Steep, rock-controlled slopes are traversed near node 8 which have potential for small debris slides or rockfalls.

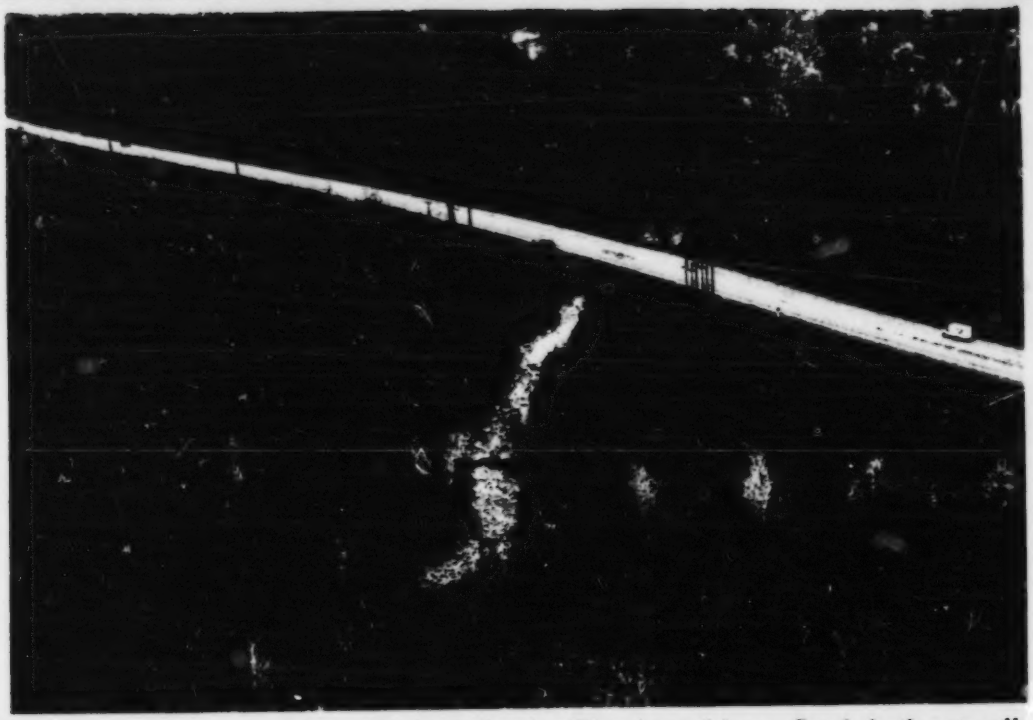


Photo 3. View west down Furlong Creek. The channel is confined, both naturally and artifically, near the apex of the fan.

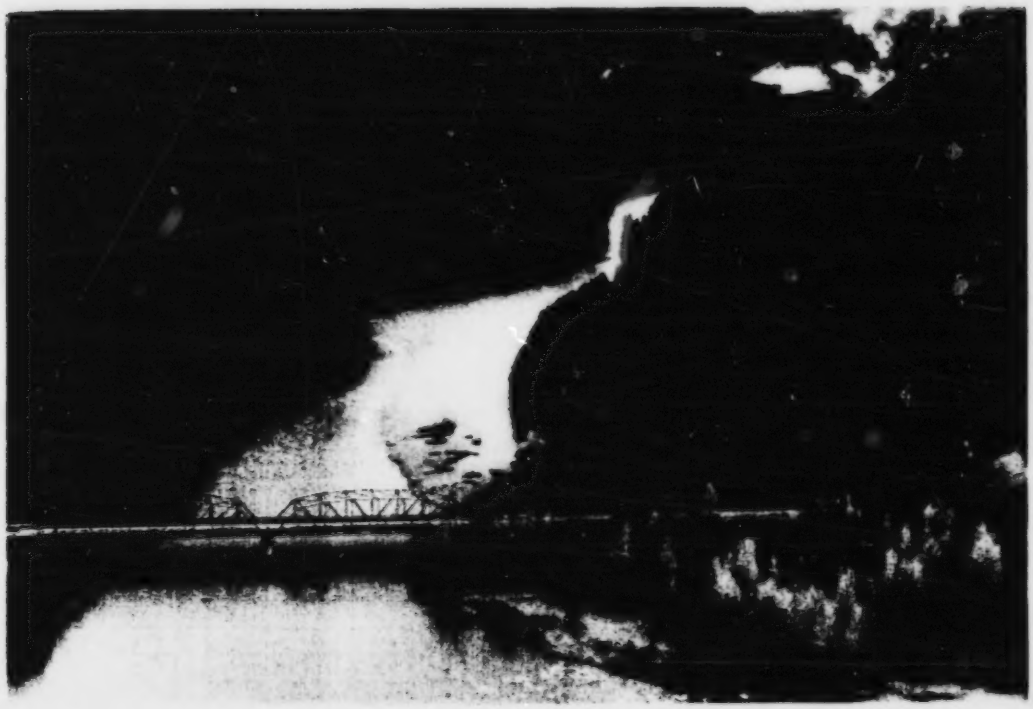


Photo 4. View east up Kitimat River. Existing towers are safely located on higher terraces away from the active channel

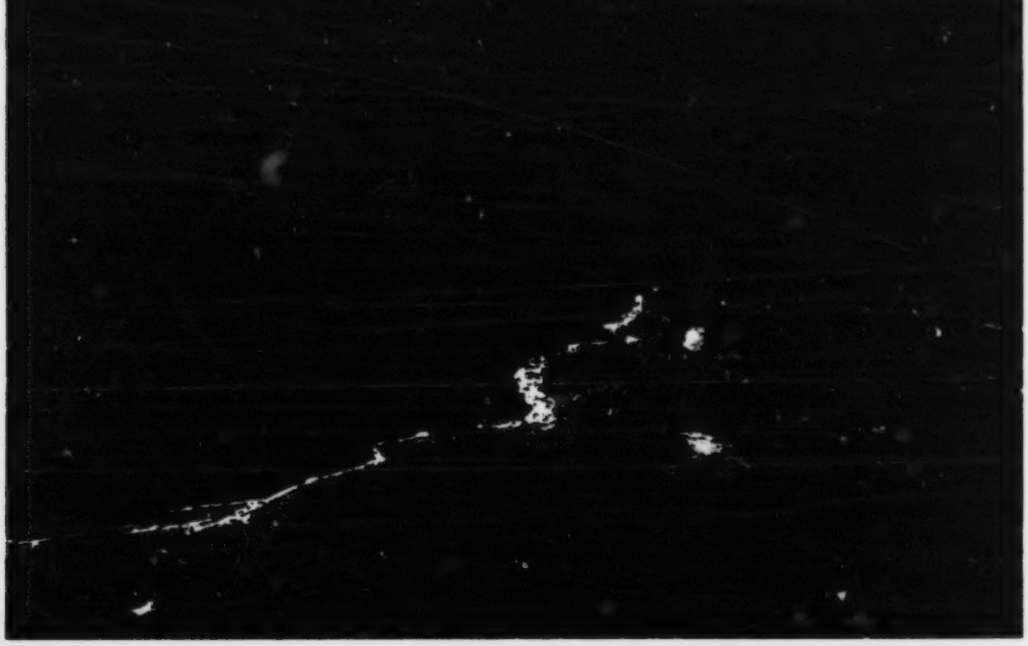


Photo 5. View east of Schulbuckhand Creek fan. Existing transmission line crosses the fan where channel shifting and fluvial erosion and deposition have recently occurred. The proposed new line would cross at the ravine mouth where the channel is confined and good foundation conditions exist.

Photo 6. Active erosion on a glaciofluvial scarp modified by gravel removal, north of Hatchery Creek. There may not be enough room for a new right--of-way between the slope and existing line.

Segment 8 - 10

- this segment drops from the rock ridge back to the existing transmission line which it parallels on the east side of the highway. For most of its length it traverses the wet low terrace which was part of Kitimat River floodplain before being cutoff by the construction of the highway. Shallow organic wetlands and frequent to occasional inundation are common constraints. Flooding is by high water table and overbank flow from tributary streams, many of which are dammed by beavers and the highway subgrade. At the south end of the segment the route climbs onto a higher and drier terrace. Excessive surface water appears to be a year-around problem on the lower terrace.

Segment 9 - 10

- this segment, parallels segment 8 -10, about 500 metres to the east, following along the base of the valley slope. Where it encroaches on the lower terrace, it will experience similar drainage and inundation problems as described for the previous segment. However, much of this route is on drier, stable ground. It first crosses hummocky bedrock on the ridge, then drops down a slope where active rockfall is occurring. This should be avoided or spanned. At the base of the slope, some glaciomarine deposits will be encountered but these mostly appear stable. In places, the route encroaches on short sections of gullied, potentially erodible moderate slopes. Streams such as Humphrys and Nalbeelah have narrow, confined floodplains which can be easily spanned. South of Nalbeelah Creek the route traverses a higher, drier terrace with small, potentially erodible scarps and a few larger wetlands in depressions. Segment 9 - 10 avoids a lot of the excessive wetness of segment 8 - 10 but encroaches on limited sections of rockfall, potential slope erosion, and glaciomarine deposits.

Photo 7. View west across Kitimat River valley. In the background, the meander-scarred floodplain is subject to flood and water table inundation. A new channel was recently eroded (centre-left), undermining a tower.

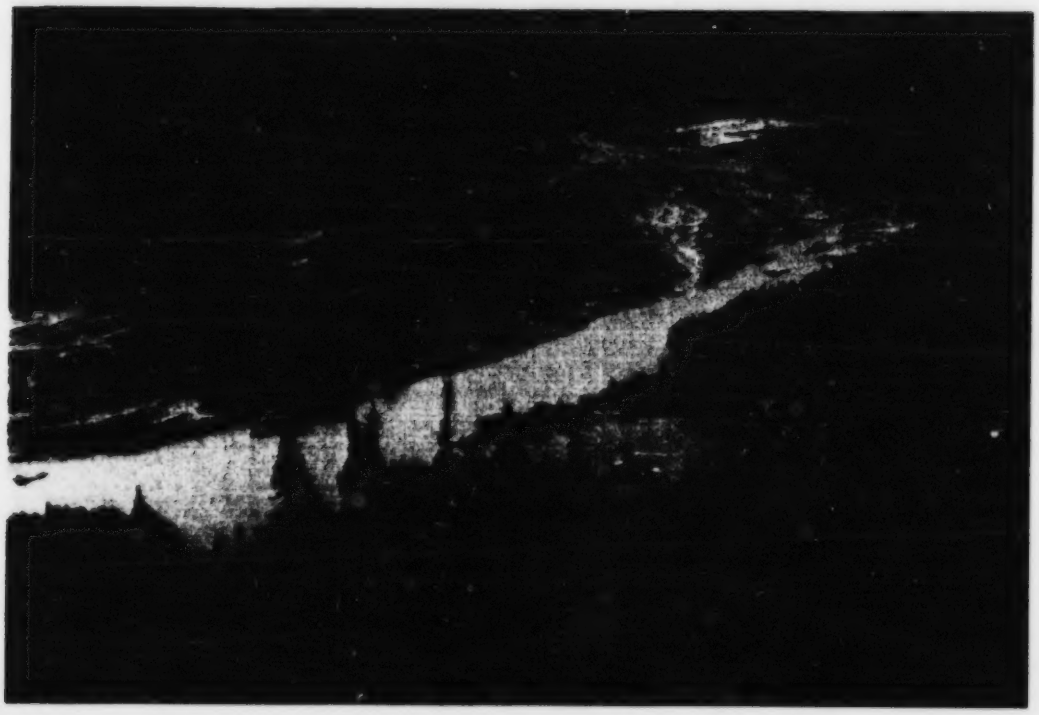


Photo 8. View south showing the old channel of Kitimat River and the new channel flowing to the right. The undermined tower has been recently armoured for protection but remains precariously situated. The tower to the east is also highly susceptible to flood damage.

Segments 10 - 11, 10 -12

- these segments are proposed to follow on either side of the existing transmission line as it crosses Kitimat valley (photo 7). Hazards on the highly active floodplain include overbank inundation, channel shifting, and lateral bank instability (photos 7 and 8). Year-around shallow wetlands occupy depressions and cut-off meanders. The zone of frequent flooding by inundation and high water table approximately follows the existing right-of-way. Consequently, segment 10 - 12 on the south side of the existing line would experience more high water than segment 10 - 11. However, route 10 - 11 encroaches on the south end of a large organic deposit in the middle of the valley. Of more concern to the integrity of the existing and proposed lines is erosion of tower foundations either by channel shifting or lateral bank instability (photo 8). Anywhere near existing or old channels should be considered highly susceptible to flood damage.

  On the west side of the valley, the routes traverse a bedrock ridge before crossing a dissected glaciomarine terrace. At node 11 - 12 gullies incised into the thick fine-textured sediments show evidence of potential erosion and slide-flows on the sideslopes (photo 9).

  Hazards posed by potential channel shifting and lateral bank instability probably create the greatest threat to the integrity of transmission lines in the entire study area. Potential erosion and mass movement in dissected glaciomarine terrain pose constraints and hazards on higher ground on the west side of the valley.

Segment 1 - 13

- this segment runs south from Skeena substation, across Lakelse River, to near End Lake. It traverses mostly subdued glaciomarine terrain with minor wetlands and isolated areas of potential erosion on small terrace scarps and incised channels. At the proposed crossing site of Lakelse River the floodplain is narrow and confined between till-bedrock hummocks (photo 10). These good foundation

Photo 9. View west at node 11 - 12 of dissected glaciomarine terrain. Disturbance of the potentially erodible and slide-susceptible gully sideslopes could cause sedimentation in the gully-bottom wetlands.

Photo 10. View north at the proposed crossing site of Lakelse River. Till-bedrock hummocks, which provide excellent foundation strength, occur on both sides of the narrow floodplain.

conditions ensure that the crossing is secure and should not significantly impact on the floodplain. At the south end of this segment the glaciomarine deposits are thinner and less extensive around bedrock ridges. Potential terrain problems on this route are minor erosion and foundation concerns on thick glaciomarine muds and the crossing of Lakelse River.

Segment 13 - 15

- this segment keeps to the east of the rock ridges, mostly traversing the near-level granular terrace surface. Potential erosion concerns occur on the incised channel sideslopes of Coldwater Creek, at the upper end of Cecil Creek gully and on the large kettle hole sideslopes (photo 11). Node 15 is located within a large unit of dissected glaciomarine sediment which shows evidence of potential erosion and mass movement.

Segment 13 - 16

- this segment follows along the base of the west valley slope, tucking in behind the large bedrock ridges protruding at the edge of the terrace surface. It traverses moderately sloping to hummocky bedrock-controlled terrain on either side of Coldwater Creek. The creek floodplain is about 250 m wide at the proposed crossing site. In a few places the route may encroach on steeper slopes which have mass movement potential. The section from Cecil Creek to Wolf Creek is mainly along a subdued granular surface. A large wetland is mostly avoided as should be the two large debris torrent fans. From node 14 to 16 the steep valley sideslopes show evidence of active and potential landsliding. The right-of-way should stay on the stable lower slopes and avoid these potentially unstable areas.

Segments 14 - 15 and 15 - 16.

- these have similar terrain concerns because they traverse thick, dissected glaciomarine deposits which show considerable evidence of potential erosion and

Photo 11. View south along segment 13 - 15 showing potentially erodible side slopes of a large kettle hole, the near-level surface of the gravel terrace, and the sideslope of a bedrock ridge.mass movement. Excessive disturbance of these materials could cause sedimentation in Wolf Creek.

Segment 15 - 21

- this segment is mostly on subdued, till terrain with few constraints other than the glaciomarine deposits at node 15 and the crossing of a small gully with potentially erodible sideslopes (between nodes 19 and 21).

Segment 16 - 22

- this segment traverses significant areas of active and potential erosion and mass movement. At Wedeene River the proposed crossing is located where large, shallow organics cover the occasional floodplain (photo 12). South of the crossing is a dissected glaciofluvial terrace with erosion and mass movement potential on the gully sideslopes. Between nodes 20 and 22, the route climbs across the oversteepened, failing and eroding, glaciofluvial terrace scarp bordering the river (photo 13).

Segment 17 - 18

- the west bank is the dissected glaciofluvial terrace with bedrock adjacent to a narrow floodplain. The east side is gently sloping till. There are good foundation conditions on both sides and the river is relatively confined at the proposed crossing site.

Segment 19 - 20

- the west bank is an actively failing and eroding scarp with less steep, stable ground above. Occasional floodplains border both sides of the active channel. The east slope is dissected glaciomarine muds with erosion and mass movement potential.

Photo 12. View west up Wedeene River. Proposed crossing site of segment 16 - 18 is located near the logging bridge. Rock outcrops occur at the base of the terrace on the north bank. Shallow organics mantle the occasional floodplain on the south side.

Photo 13. View south down Wedeene River, near node 22 and crossing segment 21 - 22. The west bank glaciofluvial terrace scarp is intensely gullied with many active landslides. Node 22 is located on the subdued surface above the scarp. The east bank is part of the occasional floodplain.

Segment 21 - 22

- the west bank is an actively failing and eroding scarp with a subdued, stable surface above (photo 13). The east bank is the occasional floodplain bordered by a higher, drier terrace. Node 21 is on gently sloping till located above a steeper, gullied till slope which is potentially erodible.

Segment 21 - 23

- this segment traverses gentle to hummocky to moderately steep till and bedrock slopes east of Wedeene River. Gullied, potentially erodible till slopes (photo 14) and steeper, potentially unstable, bedrock-controlled slopes border the floodplain but occur west of the proposed right-of-way. Good foundation conditions and few constraints occur along this segment.

Segment 22 - 24

- this segment traverses subdued to broken terrain underlain mostly by glaciofluvial and glaciomarine sediments west of Wedeene River (photo 14). North of Raley Creek the route is mostly on subdued ground above the terrace scarp. In places it encroaches on steeper, potentially erodible granular terraces. The north bank of Raley Creek has potential for erosion and slope failure; on the south side, a narrow scarp is actively failing and eroding (photo 15). South from the creek the proposed right-of-way alternates from being on stable, subdued ground to encroaching on potentially erodible granular scarps and gullies or actively failing and eroding scarps and gullies in glaciofluvial gravels or glaciomarine muds.

Segment 23 - 24

- the north bank is sloping till with some potential for erosion where gullied. An occasional floodplain borders the south side of the active channel with a higher, drier terrace behind it. Toward node 24, a slightly dissected, glaciomarine terrace with erosion potential is crossed.

Photo 14. View north up Wedeene River. Segment 21 - 23 is located at the extreme right of the photo, above the gullied till slope and staying upslope of steeper terrain bordering the river. Segment 22 - 24 is on the west side of the river, crossing Raley Creek in the upper left of the photo. Terrain on the west side is subdued to hummocky glaciofluvial and glaciomarine terraces.

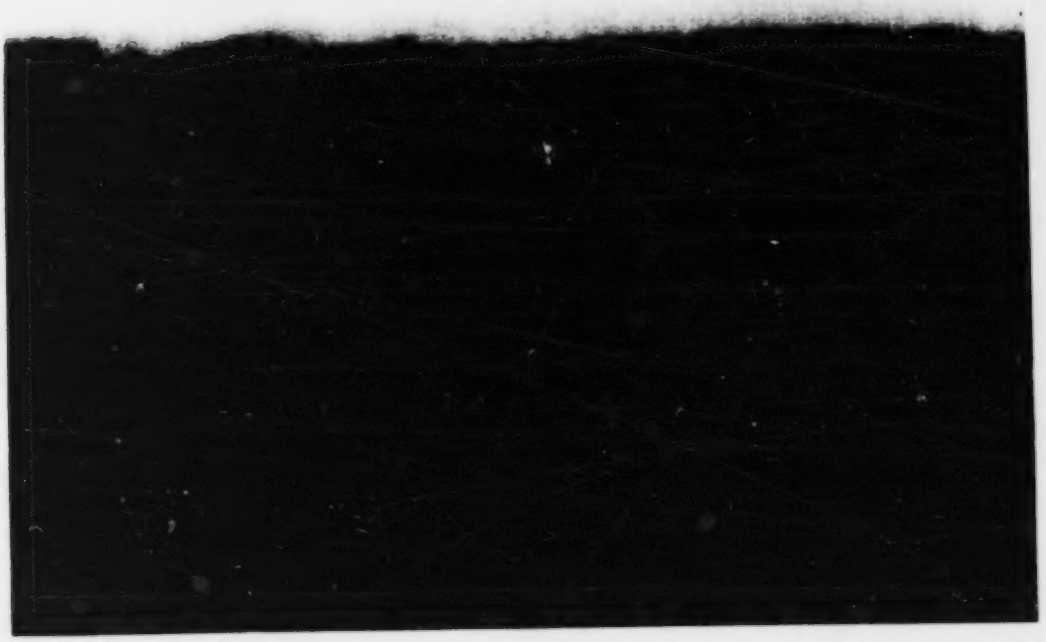


Photo 15. View west up Raley Creek. The proposed crossing is in the centre of the photo, on the first main terrace level. Actively failing slopes border the south side of the creek; the north bank has potential for erosion and mass movement.

Segment 24 - 25

- the westernmost route across Little Wedeene River climbs onto the higher terrace surface and crosses at a confined section of channel. South from node 24, the right-of-way ascends a high gravel scarp which has potential for erosion and failure; it then crosses a deep ravine with active landsliding and erosion on the sideslopes and then traverses a large organic deposit. The north bank of the river is a moderately steep gravel scarp showing evidence of erosion and failure, flattening at the edge of a bedrock canyon; the south bank slopes gently above the canyon back to an eroding and failing, gullied scarp (photo 16).

Segment 25 - 27

- this is the continuation of segment 24 - 25 on the south side of the Little Wedeene River. Much of this segment traverse a gullied scarp of glaciofluvial gravels where evidence of erosion and landsliding is common. There are areas of subdued, stable terrace surfaces between gullies and above and below the main scarp.

Segment 24 - 26 - 27

- this segment parallels the first part of segment 24 - 25 up the potentially erodible scarp and across the deep, unstable ravine. It avoids the wetland before descending the high scarp, showing evidence of erosion and failure, down to the occasional floodplain. At the proposed crossing the active channel has narrowed (photo 17) and the south bank is a higher, dry gravel terrace.

Segment 24 - 27

- this segment encounters more of the potentially erodible scarp and unstable ravine (photo 18) because it traverses along the terrace front. However, where it descends to the river, the unstable scarp is split by an intervening terrace. The river crossing site is very similar to that of segment 26 - 27.

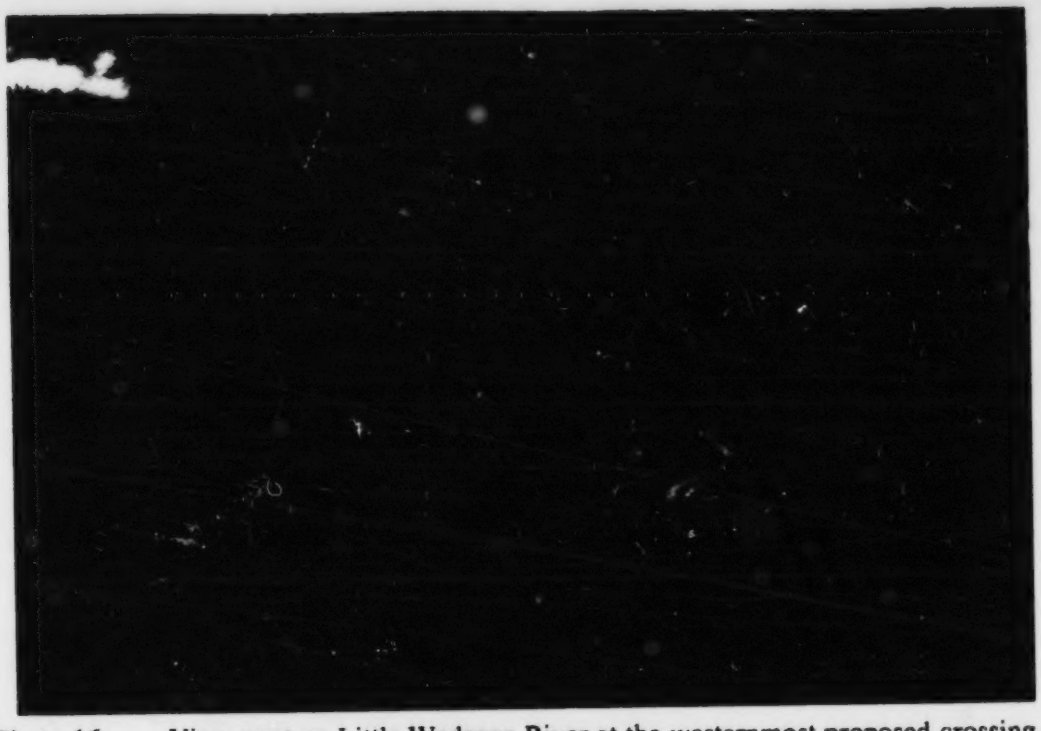


Photo 16. View west up Little Wedeene River at the westernmost proposed crossing (segment 24 - 25). The river is confined in a bedrock canyon with gentle gravel slopes on either side. On the north bank, the scarp steepens and active erosion and mass movement are occurring in places.

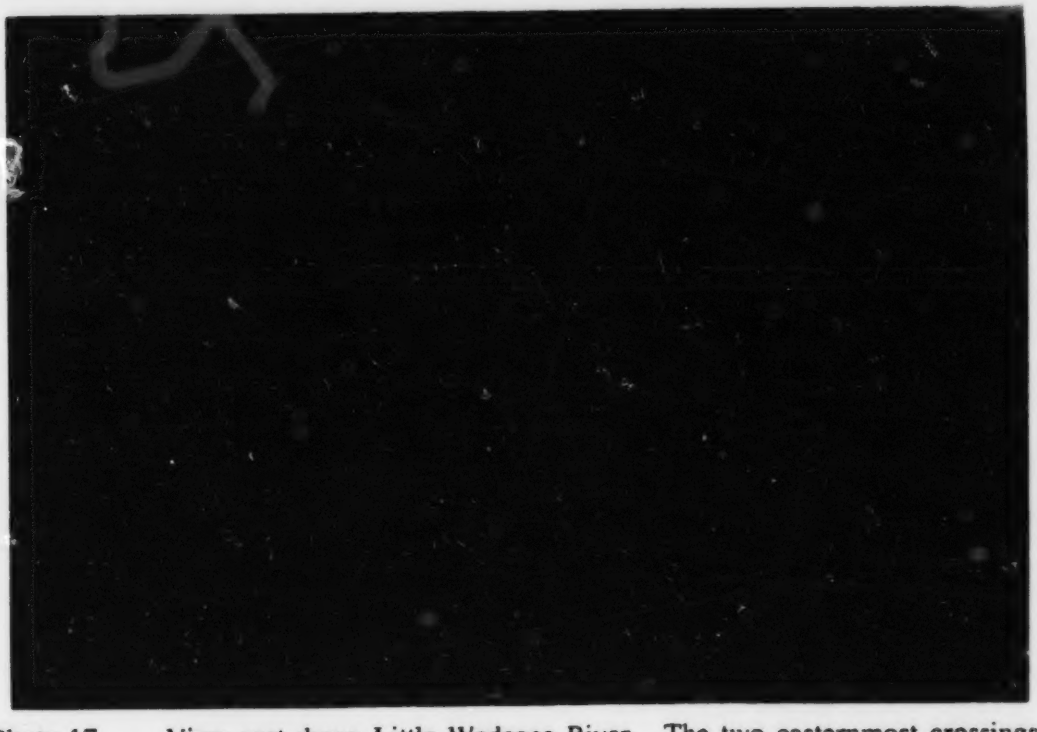


Photo 17 View east down Little Wedeene River. The two easternmost crossings (segment 26 - 17 and 24 - 27) are located in the centre of the photo where the active channel narrows. An occasional floodplain with shallow wetlands is on the north bank; higher, dry gravel terraces are on the south side.

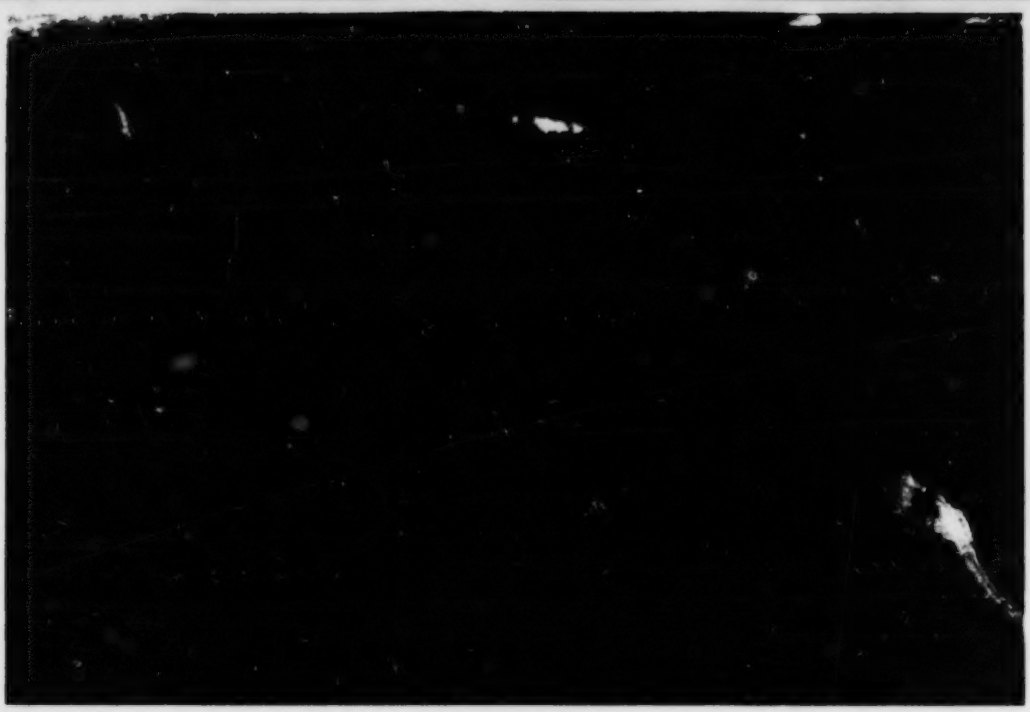


Photo 18 View west of high terrace north of Little Wedeene River which would be crossed by segments 24 - 25, 24 - 26 and 24 - 27. The latter right-of-way would be in the foreground of the photos, encroaching on the unstable ravine and scarp face.

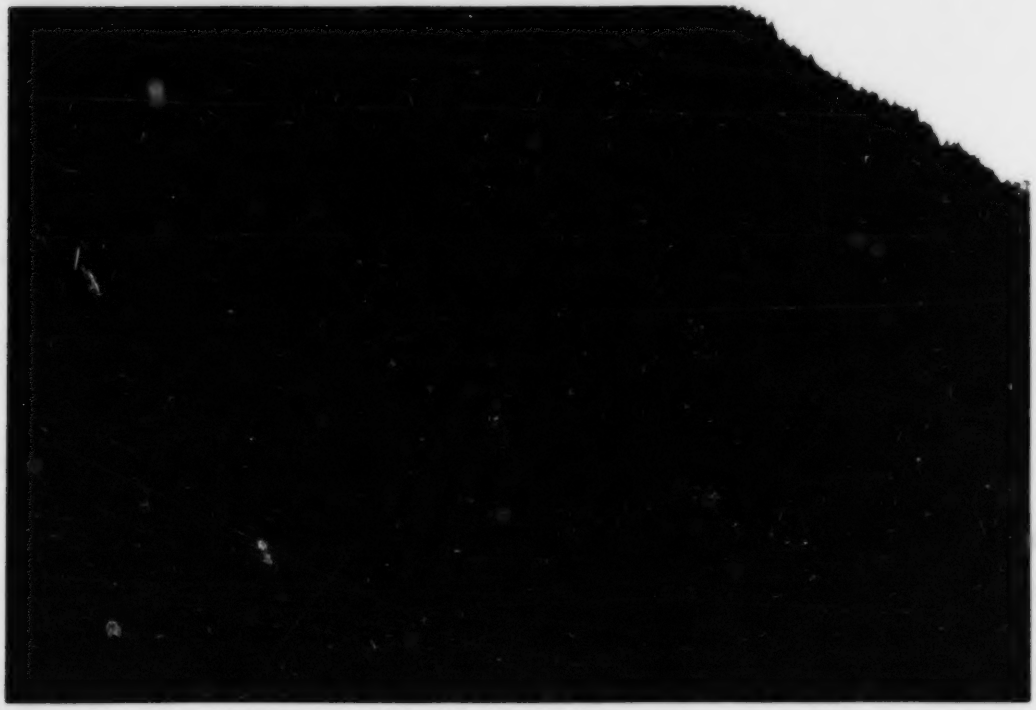


Photo 19 View north-west of steep bedrock slope subject to rockfall and some snow avalanching. Segment 27 - 11 traverses the base of this slope.

Segment 27 - 11

- this segment follows south along the base of the west valley slope, joining the existing transmission line at node 11 - 12. Rockfall and some snow avalanching occur on the steep rock slope of Little Wedeene River. Active deposition is on-going at the toe of the slope (photo 19) although stable ground occurs a short distance to the east. Slightly dissected, glaciomarine deposits which are potentially erodible are encountered south of the active rock slope. The route then climbs onto a higher glaciomarine terrace which is highly dissected with erosion and mass movement potential at node 11 - 12 (photo 9).

September 12 - 28

- this segment mostly traverses the bedrock valley wall south to the Kitimat substation. At the northern end it crosses the dissected glaciomarine muds where erosion and mass movement potential occur on gully sideslopes and soft muds and wetlands exist in gully bottoms and at the base of scarps. Stable, hummocky to moderately steep bedrock is traversed on the ridge west of Kitimat Station. The proposed right-of-way angles west from the existing line as it crosses a large glaciofluvial terrace surface. This allows it to avoid the eroding and failing scarp which is being undermined by gravel removal (photo 20). The route crosses above a deep ravine and then follows along the bedrock-controlled slope where it encroaches on steep sections of active and potential mass movement. However, stable less steeply sloping ground is plentiful in this area. Anderson Creek is confined in a bedrock canyon with the upper part of the south bank showing evidence of active erosion and failure in glaciofluvial sediments (photo 21). At the proposed crossing area, west of the existing line, the creek canyon is relatively narrow with subdued, stable, solid ground on the adjoining terrace surfaces.

Photo 20 View northwest of the large glaciofluvial terrace crossed by segment 12 - 28. The scarp is being actively undermined by gravel removal; there is no room for an additional right-of-way alongside the existing line. The proposed route traverses the moderate slope in the background, crossing above the lower segment of the deep ravine.

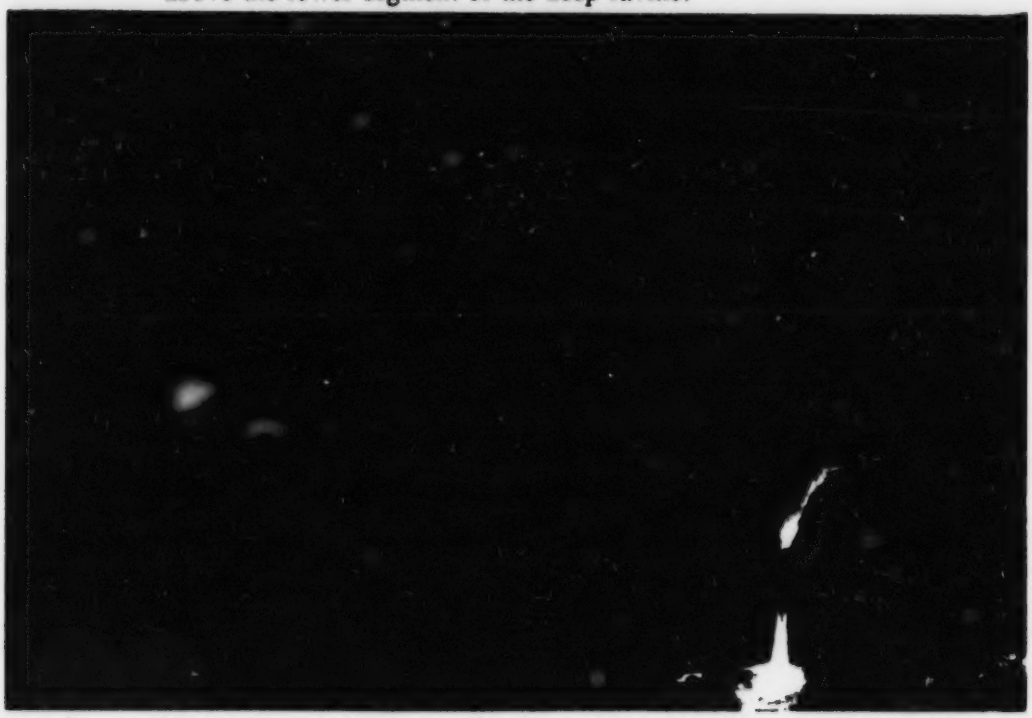


Photo 21 View west of Anderson Creek, segment 12 - 28. Actively failing and eroding terrace scarp on the south bank above a bedrock canyon. Subdued, stable terrace surfaces on both sides of the narrow gorge provide good foundations.

6.0 REFERENCES

B.C. Ministry of Environment, no date. 1:50,000 Terrain Maps, NTS 103 I/2 and 7. Surveys and Resource Mapping Branch, Ministry of Crown Lands, Victoria, B.C.

B.C. Ministry of Environment, 1988. Terrain Classification System for British Columbia (Revised Edition). MoE Manual 10. Recreational Fisheries Branch, Ministry of Environment and Surveys and Resource Mapping Branch, Ministry of Crown Lands, Victoria, B.C. 90p.

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APPENDIX A

1:50,000 SCALE
TERRAIN FEATURES
MAP FOLIO

Map Symbols

R- slopes which show evidence of active landsliding either in their natural condition or following disturbance (road construction, clearcutting).

PR- slopes which are potentially susceptive to landsliding; they are steep and/or have evidence of small failures or on-going slow movement. Disturbance to the slope could cause landsliding.

EROSION - with high local relief, fine-textured soils, and abundant precipitation the area is susceptible to surface erosion. Erosion is possible on any gullied terrain, on steep granular slopes, on glaciomarine sediments (particulary where they slope or are dissected) and on oversteepened and undercut gully, stream, and river banks. Exposing bare soil during construction increases erosion potential. Downslope or downstream sedimentation is the main result of slope erosion.

Map Symbols

E - active or on-going soil erosion

PE - terrain which is potentially susceptible to surface erosion; slopes, gullies and stream banks appear stable but could erode if disturbed by road construction or deforestation.

DEPOSITIONAL AREAS - along with active landsliding, surface erosion, and snow avalanching on slopes, areas of active deposition from these processes should also be considered hazardous. Where on-going accumulation from landslides or snow avalanches is evident worker safety, towers, and access roads may be threatened.

Map Symbols

D - toe-slope areas regularly receiving deposition from upslope debris slides or flows or rockfalls.

Rt - fans built at the mouths of steep-gradient gullies subject to debris torrent flows; debris deposition, erosion, and channel shifting may occur anywhere on the fan.

SNOW AVALANCHING - The rapid downslope movement of snow, ice, and incorporated debris occurring in areas of high local relief and moderate to high snowfall. Winter and spring avalanche activity poses a direct hazard to tower integrity, access, and worker safety.

Map Symbols

A - Slopes subject to regular snow avalanching; includes zones of initiation, transportation, and deposition

FLOODING - Climate and physiography of the study area make floods inevitable. Potential flood areas include active channels and low terraces of rivers and streams and some alluvial fans at the mouths of tributary valleys. Hazards from flooding include overbank inundation, channel shifting, and laterally eroding banks. Flooding typically is of two types: fall-winter floods triggered by intense rainstorms, sometimes accompanied by rapid snowmelt and spring-early summer floods caused by melting of the winter snow pack.

Map Symbols

F - areas subject to frequent flooding - 1 to 3 year return

O - areas subject to occasional flooding - less than 50 year return

TERRAIN ANALYSIS LEGEND
SCALE 1:50,000

WETLANDS - depressional areas which are poorly drained for most of the year; inundation from high water table or lake or stream flooding is the main constraint but soft, compressible soils are also common.

Map Symbols

W1 -dominantly organic materials greater than 1m thickness
W2 -organic deposits of variable extent and thickness (40-150 cm)
W3 -thin organics (less than 1m) and poorly-drained mineral soils; overbank silts and fine sands occur on wet floodplains, glaciomarine muds underlie other valley bottom depressions.

FINE-TEXTURED SURFACE MATERIALS-

glaciomarine muds consisting of a mixture of clay, silt and minor sand. These have relatively high bearing strengths when dry but virtually none when saturated. They may liquefy and flow, even on gentle gradients, when disturbed.

Map Symbols

f1 -dominantly thick (greater than 2m) deposits
f2 -deposits of variable thickness - 50 - 200 cm
f3 -disturbed or reworked muds as the result of saturation.

TOPOGRAPHY - Steeper uniform slopes and broken, irregular topography are identified because they may be associated with potential mass movement and erosion and also may pose some access or construction constraints.

Map Symbols

s -slopes dominantly greater than 70% (35°)
k -slopes dominantly between 50 - 70% (26 - 35°)
h -hummocky and/or ridged terrain
d -highly dissected terrain; gullied, channelled or pitted surfaces

BEDROCK - bedrock is often an excellent foundation material but is more difficult and expensive to excavate (for access roads or tower construction)

Map Symbols

r -bedrock at or within 50 cm. of the ground surface

MASS MOVEMENT- with high local relief and abundant precipitation the area is susceptive to landslide failures. On steep, bedrock-controlled slopes, the main landslide types are debris slides and flows, debris torrents (channelized flows), and rockfalls. On thicker, valley-bottom surficial deposits, slides are common on oversteepened terrace scarps and on glaciomarine deposits, particularly where gullied. Landslides can threaten tower foundations, access, and worker safety.

Map Symbols

R- slopes which show evidence of active landsliding either in their natural condition or following disturbance (road construction, clearcutting).
PR- slopes which are potentially susceptive to landsliding; they are steep and/or have evidence of small failures or on-going slow movement. Disturbance to the slope could cause landsliding.

EROSION

MAPS
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